A

DESCRIPTION

OF THE

NATURE, CONSTRUCTION, and USE

OF THE

Torricellian, or *Simple*

BAROMETER.

WITH A

SCALE of RECTIFICATION

For eſtimating the True Altitude of the Column of Mercury (equal to the Weight of the Atmoſphere) to the Hundredth Part of an Inch.

ALSO

The THEORY and CONSTRUCTION of the *Compound* BAROMETER; the Nature and Uſe of the THERMOMETER, and HYGROMETER.

With an APPENDIX.

Containing an *Analytical* SOLUTION of a BAROMETRICAL PROBLEM. The whole illuſtrated by Copper-Plate Figures of the ſeveral Inſtruments.

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PREFACE.

I KNOW there are other Conſtructions of a Scale for rectifying the ſmall Error of the Barometer, but they are, in my Opinion, not ſo juſt, natural and eaſy to be uſed, as that of Mr. AMONTON'*s, which is here adopted.*

Nothing tends to depreciate the moſt valuable Inſtruments ſo much as an Ignorance of their Nature and Uſe; moſt People expect to ſee the Alterations of Weather immediately by the Barometer, *but ſuch an Inſtrument was never intended to ſhew any thing more than the Variations that happen in the* Weight of the Air only. *The Changes of Weather are only in Conſequence of them, and are of too precarious a Nature to admit of any certain Indication, much leſs Prediction,*

diction, by any human Art or Contrivance whatſoever.

But as the Barometer never fails to ſhew the true Cauſe of the Alterations of Weather, we are thereby prepared to expect them; and that too, in a Degree proportioned, in general, to the Height of the Mercury in the Barometer; the Rationale of this uſeful Inſtrument will be eaſy to underſtand, from a due Conſideration of the following Operations of Natural Chemiſtry: viz.

Firſt, *The Atmoſphere is well known to be a* Diſſolvent Medium, *with reſpect to* Water, Vapours, Clouds, *&c. in the ſame Manner as* Spirit of Nitre *is to Metallic Bodies, Silver, Copper, Iron, &c. that is, all aqueous Subſtances are diſſolved by, and converted into Air; and, of Courſe, muſt add much to the Weight of the Atmoſphere. Hence the Clouds being diſſolved, the Air becomes heavier, the Weather* Fine or Fair, *and the Barometer* riſes *in conſequence of this ſuperior Weight.*

Secondly,

Secondly, *On the other Hand, Nature employs a principle of* Precipitation, *when neceſſary, by which the aqueous Parts of the Air run and embody together, form Clouds, Fogs, &c. which agitated by the Winds, diſperſe their Subſtance in* Showers; *and as the Air is, by this Means, rendered lighter, the Mercury muſt fall in the Tube ſome little Time before, by which we expect that* foul, *or* rainy Weather, *will follow.*

Thirdly, *When the Atmoſphere is charged with more aqueous Matter than it can diſſolve, the Surplus will form Clouds, and theſe produce* Showers of Rain, *when the Barometer ſtands* very high; *and for the contrary Reaſon, there may ſometimes be* no Rain, *when the Mercury is* very low. *Hence it follows, that we are generally ſatisfied by this Inſtrument what Weather we may at all times* probably *expect, though ſometimes* poſſibly *the contrary may happen, And a* general MONITOR *(to any* wiſe Man) *is better than none at all.*

Directions *for filling the* Tube *of the* Barometer *with* Quickſilver.

WHEN you have fixed the Barometer in that Part of the Room moſt ſuitable, ſcrew it up very faſt; then take out the Tube and warm it by the Fire, pour the Quickſilver through the ſmall Paper Funnel that is ſent in the Box, 'till it be filled within an inch of the Top; then, placing your Finger on the open End, incline the Tube ſo far that the Bubble of Air may run up through the Quickſilver to the Top. Then, again, holding the other End upwards, the large Bubble of Air will re-aſcend to the Finger, and gather all the ſmall Bubbles of Air out of the Quickſilver, and leave it quite fine.—This done, hold the Tube upright and fill the remaining Part quite to the Top, then pour the Remainder of the Mercury into the Wooden-baſon at the Bottom of the Barometer, and, placing the Finger firmly on the End of the Tube, invert it, and place the End with the Finger upon it under the Mercury quite to the Bottom of the Baſon, where taking away the Finger, the Mercury will ſubſide and ſtand to its proper Height in the Tube, which then may be faſtened to the Frame in the Manner you find it ſent; then putting the Cover over the Mercury in the Baſon, the Work is finiſhed, and the Barometer will always go true.

N. B. To the Frame juſt over the Baſon is fixed a ſmall Piece of Box, to the End of which the Mercury ſhould riſe, and juſt touch it; but if more be put in than will ſuffice for that, it muſt be taken out with the Bowl of a Tobacco Pipe, or ſmall Funnel of Paper, till it deſcends to the ſaid End of the Box.

A DESCRIPTION *of the* NATURE CONSTRUCTION, *and* USE *of the* Torricellian BAROMETER *rectified for* Philoſophical ENQUIRIES.

THE Inſtrument we call a BAROMETER, both in Regard of Curioſity and Utility, has always been eſteem'd the firſt in Dignity among the modern Philoſophical inventions. The Uſe of it, is, as it's Name imports, to *meaſure the Weight of the Air* at all Times, and to indicate minutely and momentarily it's Variations and Changes in that Reſpect.

The *Weight of the Air* is the moſt important Principle in Nature, and tho' it is capable of being demonſtrated many Ways, yet there is none ſo direct, eaſy, and natural, as that of the BAROMETER, which will evidently appear from the very Deſcription of it.

A BAROMETER of the moſt ſimple form, conſiſts of a ſtrait Glaſs Tube hermetically cloſed at one End, and being filled with Mercury, is inverted with the open End into a Baſon of the ſame Fluid, in ſuch a Manner that no Air can get into the Tube in the Operation;

then the Body of the Mercury in the Tube (thus inverted) will ſubſide to a certain Diſtance from the Top, where it will reſt upon a Column of Air of equal Weight and contrary Preſſure.

By this Definition of a Barometer, it appears that ſince the Column of Quickſilver in the Tube is ſuſtained by, and depends wholly on an equal and contrary Preſſure of the Atmoſphere, the Altitude of that Column of Mercury in the Tube muſt neceſſarily be an *adequate Meaſure* of the Weight or preſſure of the Air upon the ſame Orifice, or Area, of the Bore of the Tube.

By conſtant Experience it has been found, that in our Climate, or Iſland, the Height of this Column of Mercury in the Barometer has never exceeded *thirty-one Inches*, or been leſs than *twenty-eight*. Therefore the *Scale of Variation* is three Inches, which is about a *Tenth Part* of the whole Height. This Scale of three Inches is placed with its loweſt Part juſt twenty-eight Inches from the Surface of the Mercury in the Baſon at the Bottom of the Frame.

In order to ſhew that a Barometer conſtructed in this manner, is the *only One* that will admit of *Perfection*, or go at all Times *preciſely true*, it will be neceſſary to repreſent the upper Part thereof as in Fig. 1. But becauſe a Barometer will be inevitably deficient in a ſmall Degree without a THERMOMETER, (as we ſhall ſhew by-and-by,) therefore theſe two Inſtruments are neceſſary Companions, and ought always to be placed by each other, in a Frame. To theſe I add a third, which is a very uſeful Inſtrument, called

called a HYGROMETER, and ſo make a *triple Weather Glaſs* for anſwering every Purpoſe.

Theſe three Inſtruments are ſhewn in Plate I. Figure I. Where A B C is an engraved Braſs, Ivory or Silver Plate, in which they are all contained, with their proper Scales. In the Middle Part of this Plate is cut a long Slit fit to receive and contain the upper Part of the Barometer Tube D E F, in which the Top of the Column of Mercury appears at E; all the Space above to the Top at F, being void of Air.

On the Right-hand Side of the Tube D F is the Scale of four Inches C G, *viz.* from twenty-ſeven to thirty one, and the Number twenty-ſeven, is juſt twenty-ſeven Inches from the Surface of Quickſilver in the Baſon below. Hence as the Surface of the Mercury at E riſes and falls with the Variation of the Air's Gravity, that will be denoted, and its Height meaſured, by an Index at H, which Slides up and down, in a proper Groove, and is fixed to any Part, as occaſion requires.

The Altitude of the Mercury is meaſured by a ſimple Index only, in Inches and Tenths of an Inch, which for all common Uſes is ſufficient to indicate the general Alterations in the Weight of the Air, and, of courſe, the Changes of Weather.

But thoſe who chuſe to be more accurate, and are curious in phyſical Reſearches, may have this *Scale of Variation* ſtill more minutely divided by a little moveable Slip of Braſs (or Ivory) H I, containing *ten equal Parts* or Diviſions, which together are juſt equal to *eleven* of thoſe on the Scale of Variation, that is, to eleven Tenths of an Inch.

By

By this Artifice the Height of the Mercury at E is evident, by Inſpection only, to the $\frac{1}{100}$ (*hundredth Part*) of and Inch. That this may be underſtood, nothing more is neceſſary than to conſider, that *one Tenth Part of a Tenth of an Inch*, is the *one hundredth Part of an Inch*. Now every Tenth of an Inch in the Scale C G is divided into ten equal Parts, by the Slip (called a *Vernier*) H I; for ſince ten Diviſions on that, exceed ten on the Scale by one Diviſion, that is, by one tenth of an Inch, therefore one Diviſion on the *Vernier* will exceed one Diviſion on the Scale by *one Tenth Part*; and two Diviſions on the *Vernier* will exceed two on the Scale by two Tenths, and ſo on: Therefore every Diviſion on the *Vernier* will exceed the ſame Number of Diviſions on the Scale *by ſo many Tenths of a Tenth*, or by *ſo many Hundredth Parts of an Inch*.

Therefore when the *Vernier* is uſed, the ten equal Diviſions of an Inch on the Scale C G, muſt be looked upon as ſo many *Ten Hundredth Parts of an Inch* and numbered thus, 10, 20, 30, 40, *&c.* Parts of an Inch, then the *Vernier* gives the Units to each ten, thus; ſet the Index H very nicely to the Top of the Surface of the Mercury E, and if at the ſame Time the Beginning of the Diviſions at H coincides with a Line of Diviſion in the Scale C G, then it ſhews the Altitude of the Mercury in Inches and Tenths of an Inch exactly.

But ſuppoſe the Index Line H of the *Vernier* falls between two Diviſions or Tenths on the Scale C G, then there will be a Coincidence of Lines in both at that Number of the *Vernier* which ſhews how many Tenth Parts of that Tenth the Index

Index of the *Vernier* has paſſed the laſt decimal Diviſion of the Scale: Thus for Example, ſuppoſe the Index of the *Vernier* were to point ſomewhere between the 8th and 9th Tenth, above 29 on the Scale, then if by looking down the *Vernier*, you obſerve the Coincidence at Number 7, it ſhews that the Altitude of the Mercury is 29 Inches and 87 Parts of a Hundred of another Inch.

Where ſuch great Preciſion is required, ſeveral Circumſtances muſt be attended to, which in common Uſe are not ſo very material; as (1.) A Tube with a large Bore, 3 or 4 Tenths of an Inch Diameter, that the ſurface of the Mercury in the Tube may be nearly *plane*, and not ſenſibly *convex*, as in thoſe of a ſmaller Size. (2.) That a *Magnifying Glaſs* be applied in ſetting the Index of the *Vernier* moſt accurately to the Edge of the Surface of Mercury. (3.) That the Surface of the Mercury in the baſon below, be ſo large that its Altitude may not ſenſibly vary with that of the Mercury in the Tube. (4) That the Error the Barometer is liable to from *Heat* and *Cold*, be well corrected.

Theſe two laſt Articles merit a more particular Conſideration, as upon them the great Perfection of this Inſtrument depends. As in this ſimple Barometer the Scale of Variation is near three Inches, it is therefore to be ſuppoſed, that theſe three Inches of Mercury in the Tube may all go into the Baſon at Bottom without any ſenſible Elevation of its Surface, and this we may reckon about the *Hundredth Part of an Inch*.

Therefore if the Diameter of the Tube be given, you find the Diameter of the Baſon of a Cylindric

Form,

Form, ſuch that three Inches of Mercury in the given Tube ſhall make a Riſe of only $\frac{1}{100}$ of an Inch in the Baſon, by this Rule —— *Multiply the Square of the Diameter of the Tube by* 300; *then the Square Root of that Product will be the Diameter of the Baſon required.*

For Example, let the Diameter of the Tube be $\frac{2}{10}$ of an Inch, the Square thereof $\frac{4}{100}$, which multiplied by 300 gives 12, the Square Root of which is 3,46 or $3\frac{1}{2}$ Inches nearly, for the Diameter of the baſon required. By this Rule, a Tube of $\frac{3}{10}$ of an Inch, will require a Baſon near $5\frac{1}{2}$ Inches Diameter; and a Tube of $\frac{4}{10}$, will have a Baſon 7 Inches Diameter nearly.

In the Year 1765, on the 28th of March, the Mercury was at 28,21 Inches; and on January 29th 1766, it roſe to 30,76 Inches; theſe are the greateſt extremes I ever obſerv'd, which give a difference of 2,55 Inches.

Indeed, as there ſcarce ever go 3 Inches of Mercury out of the Tube into the Baſon, we may take $2\frac{1}{2}$ at a Mean; and inſtead of 300, multiply by 250; the Diameter of the Baſon will be large enough for Uſe, even to the moſt curious.

The fourth Article mentioned as requiring the Attention of the *Virtuoſo*, is the Error that ariſes from the Alteration of the Bulk of Quick-ſilver by Heat and Cold; every one knows that all Bodies, Solid or Fluid, have their Bulks encreaſed by Heat, and leſſened by Cold; and conſequently their Specific Gravities will decreaſe and encreaſe proportionably at the ſame time, and from the ſame Cauſes.

Hence

Hence it follows that a Column of Mercury 28 or 31 Inches high, is not ſo heavy in very hot weather, as it is in very cold Weather. Since, then, a Column of Mercury of the ſame Height has a different Weight in different Temperatures of Weather, it may in theſe different States of Weather, indicate the ſame Weight of the Atmoſphere, though the real Weight be variable all the While. For Example, the Air is conſiderably lighter when the Mercury ſtands at 30 Inches in hot Weather than it is when the Mercury has the ſame Height in Weather that is very cold.

Hence it appears that in order to correct the Altitudes of Mercury in the Barometer, it will be neceſſary to know in what Ratio Mercury expands in a given Degree of Heat. This we have determined to our Hands by the Experiments of the celebrated Mr. AMONTONS, who found that a Column of Mercury of 115 Lines in great Cold extended to 116 Lines with great Heat; and becauſe 12 Lines make a *French* Inch, therefore 3 time 115 Lines is 28 Inches 9 Lines; and 3 times 116 is 29 Inches, and conſequently in 29 Inches, there was an Extenſion of 3 Lines.

Theſe two Extremes of Cold and Heat in his Thermometer were at 50 and 58, which in *Farenheit's* anſwer to 20 and 88. And ſince the Proportion of the *French* Foot is to the *Engliſh* Foot as 128 to 120, therefore 29 *French* Inches is near equal to 31 of ours. Hence then, as 29 *French* Inches contain 348 Lines, and 31 *Engliſh* Inches contain 310 Tenths of an Inch; if we ſay, as 348 is to 310, ſo is 3 Lines to 2, 7 Tenths of an Inch *Engliſh*; this laſt Number

will be the Extenſion of a Column of Mercury 30 $\frac{73}{100}$ Inches high.

If then we take 29½ Inches Height of Mercury for the Mean Weight of the Air, and ſay as 310 is to 27, ſo is 295 to 26, nearly; it will appear that the Mean Variation of the Column of Mercury from the Cold of 20 Degrees to the Heat of 88 in *Farenheit's* THERMOMETER is 26 Hundredth Parts of an Inch.

Conſequently if a Scale of 26 *equal Parts*, equal in Length to the Diſtance between thoſe two Points of 20 and 88 Degrees, and placed by the Thermometer in a correſponding Poſition, it will always appear by Inſpection of the Thermometer how many of thoſe 26 hundred Parts of an Inch are to be deducted from the preſent Height of the Mercury in the Barometer, to have the *true Height*, or that which is owing to the *Weight of the Air alone*.

This Correction of the Barometer is in a *Mean* Degree, 'tis true, but it is ſo very near the Truth, that the moſt ſcrupulous Enquirer into Nature cannot well complain of it's Deficiency; eſpecially if it be conſidered that the Altitude of the Mercury is moſtly between 29 and 30; and, of Courſe, where there can be no ſenſible Error at all.

However to exempt the *ſimple Barometer* from all Imputation of Error, nothing more is neceſſary than an eaſy Operation by the *Rule of Three*; for ſuppoſe the Index of the *Vernier* gives the Height of the Mercury 29,37; and the Thermometer ſtands at 63, then in the Scale againſt 63 is 16½ Hundredths of an Inch, to be deducted from the preſent Altitude 23,37; which

which will give 29,205 for the Altitude near the Truth, by the *Scale alone*.

But to have the Altitude preciſely true, theſe $16\frac{1}{2}$ Hundredths of an Inch muſt be added to the greateſt Altitude 30,73, which will give 30,895 for the greateſt Altitude the Mercury could have with the preſent Degree of Heat 63. Then ſince the Expanſions are as the Altitudes of the mercurial Columns, we ſhall have, by the Rule of Three, this Analogy, as the greateſt Altitude (with the preſent Heat) 30,895 is to the preſent Altitude 29,37, ſo is the Expanſion 16,5 for the greateſt Altitude, to the Expanſion 15,686 due to the preſent Altitude, which being deducted from 29,37 leaves the true Altitude 29,213, which is but $\frac{8}{1000}$ of an Inch more than before.

From hence it appears, that the Errors of the ſimple Barometer are to be corrected without any Trouble, even as it were by the Glance of the Eye: But this will be rendered ſtill more intelligible by Fig. 1. wherein A M is *Farenheit's Thermometer*, with it's proper *Scale of Degrees of Heat*; and K L the *Scale of Rectification* for the *Barometer*, containing the 26 Hundredths of an Inch, as above determined, and which begins from the 20th Degree. And thus the whole Matter is compriſed and repreſented in one ſimultaneous View.

But one Thing is to be obſerved, *viz.* that the *Rarefaction of the Mercury* has been hitherto only conſidered, above the *ſtandard Denſity* which it has at the 20th Degree of the Thermometer, and when the Altitude thereof in the Barometer does juſtly indicate and meaſure the true Weight of the Air. But ſince in all De-

grees of Cold below 20, the Denſity of the Mercury will be greater than the ſtandard Denſity at 20, therefore the Columns of Mercury in all ſuch Degrees of Cold will be too ſhort to meaſure the true Weight of the Air; and conſequently will require an *Addition* of ſo many of thoſe 26 Hundredth Parts as correſpond to the Height of the Thermometer. But it is a hard Froſt at 20 Degrees, therefore it will rarely happen that the Column of Mercury will be too denſe or heavy; and conſequently a few of theſe additional Parts will ſuffice.

From this Account of the Nature of a *Barometer* it is evident, that which is here ſpecified has the following peculiar Advantages, *viz.*

Firſt, It is the moſt *ſimple*, *compendious*, and *facile Conſtruction that ſuch an Inſtrument is capable of*; there is only one ſtrait glaſs Tube, and one Fluid only, and there cannot be leſs of either. Alſo it is filled, and placed in a proper Manner, without any Trouble, and in a few Minutes Time, by any Perſon of common Underſtanding.

Secondly; The Scale of this *Barometer* is fixed independently of the Inſtrument itſelf; and is of one abſolute and determinate Meaſure, ariſing from Nature, and not from the uncertain Fancy and Caprice of the Artiſt, as it neceſſarily does in other Conſtructions.

Thirdly; The two Fluids of *Air and Mercury* are here in immediate Contact, and always mutually ſuſtain each other in the *moſt perfect Equilibre*; for the Tube being of a proper Size, there can be no Coheſion between it and the Mercury, to obſtruct the Motion of the latter; and there being no other poſſible impediment

to

to its free Motion arising from the Construction, the Altitude of the Mercury must always vary with the minutest Variation in the Weight of the Atmosphere. Whereas in all *Mechanical* and *Compound Barometers*, the *Friction*, *Adhesion*, *&c.* arising from the Mechanism, Smallness of the Bore, and other Causes, are of such a Nature as will not admit of their being removed or annihilated by any Means whatsoever.

Fourthly; By the Use of the *Vernier*, the Scale of this Barometer is enlarged *Ten Times*, or 3 Inches is thereby rendered equivalent to 30 Inches; which is as great an Extension of the Scale as you have in the *Compound Sort*; without encreasing the natural Error of the Instrument, which in all others is unavoidable.

Fifthly; The Error from Heat and Cold, which naturally attends every Construction of a Barometer, is totally corrected in the *simple Barometer*, as we have shewn; but in no other Sort can this be done, without immense Difficulty and great Expence, as any one may be convinced who will give himself the Trouble to peruse Mr. Saurin's Discourse on this Subject in the *Memoires of the Royal Acad. of Sciences for the Year* 1727. And even there it will be found a Matter more of Speculation, than of Practicability.

Sixthly; The *simple Barometer* is not in itself liable to be impaired, or out of Order, and when by Accident it becomes so, there is scarce any Trouble or Expence attends its Reparation; but in all compound and mechanical Barometers, we experience the contrary in every Respect*.

These

* I take no Notice here of the *Portable Barometer*; its Structure being every Way so absurd, as renders it unfit for Use even to the most Ignorant and Incurious.

Theſe are ſome of the peculiar and moſt eſſential Properties of the *ſimple Barometer* properly rectified, and which cannot fail to give it the Preference with all judicious People. I do not ſay any Thing with regard to the Moderateneſs of the Purchaſe in Compariſon of other Barometers, though this is an Argument that may have ſome Weight with thoſe whoſe Purſes are light, and who do not chuſe to pay for having a good Inſtrument ſpoiled.

I could never have believed, had I not been too well convinced of it by Experience, in many Inſtances, that the Ingenuity of Men ſhould be employed to pervert the Intentions of Nature, in *making that wrong* with a great deal of Art, Expence, and Difficulty, which ſhe has benignly *conſtructed right* with ſo much Simplicity, Perſpicuity, and Eaſe*. But in no one Caſe is this abſurd Procedure ſo notorious as in that of Barometers. Had we, on the contrary, aſſiſted Nature, and rectified the Barometer originally with the *Vernier* there would have been no Occaſion for HUGENIUS to have added a Column of Water to that of the Mercury, and much leſs of Mr. DE LA HIRE's third Column of another Liquor upon that. If the Tenth of an Inch be divided into 20 Parts by the *Vernier* (as it very well may) then will the Scale of 3 Inches be rendered equivalent to a Scale of 60 Inches, or *Five Feet* in Length, and the Weight of the Atmoſphere be determined to the two hundredth Part of an Inch in the Height of the Mercury, which is a much greater Degree of Accuracy than the *Wheel-Barometer*, the *Diagonal-Barometer*, the *Horizontal-Barometer*,

* Glaring Inſtances of this Kind may be often obſerved in the *Fabrications* of *Microſcopes*, *Clocks*, Orreries, &c.

ter, &c. can pretend to, with all the Pomp and Vanity of ſuch *preternatural* Conſtructions.

But it will avail little to argue on this Head; the Judicious need it not, a Word to them is enough; the Injudicious will not regard it, ſay what you will, their Caſe is too much like that of the *Blind, who ſwallow many a Fly*, and rather deſerves Commiſeration than Reflection. However, that it may not be thought I decry other Forms and Conſtructions of Barometers without giving Reaſons for it, I ſhall lay before the Reader the Conſtruction and Theory of the *Carteſian* BAROMETER, which is certainly the beſt of all the bad Sorts.

This double Barometer conſiſts of two Parts or Tubes, *viz.* one that holds the Mercury, and the other, a ſmaller Tube, with a tinged Liquor, *viz. Spirit of Wine.* Theſe are both connected together, and communicate with each other. The firſt, which holds the Mercury, has a large *Cylindrical Part*, denoted by A B C D, hermetically ſealed on the Top; this is joined to a recurved Tube E F G of a proper Length, to which, on the lower Part, is another Cylinder H I K L affixed, equal to that above in Diameter; upon the Top of this is a ſmall Tube M N O, of a ſufficient Length for the tinged Liquor to move in.

One Part of this compound Inſtrument is filled with Mercury, ſuppoſe from P in the Cylinder above, to Q in that below; and the coloured Spirit fills the other Part of this Cylinder from Q to K, and from thence to N in the ſmall Tube. This repreſents the State of ſuch a Barometer for ſome particular Weight of the Atmoſphere.

But

But when this Weight of Air alters and becomes (ſuppoſe) lighter, then will the Mercury ſink from P to R in the upper Cylinder, and riſe through an equal Space from Q to T in the lower one, which will cauſe the tinged Spirit to riſe into the ſmall Tube, and to aſcend therein from N to O.

Now in order to find what different Height of Mercury in the Common or Simple Barometer correſponds to this Difference N O in the Height of the Spirit, it muſt be conſidered that if in the firſt State of the Air, when the Spirit was at N, the Spirit were taken away, and juſt ſo much Mercury put into the Cylinder I K as would have the ſame effect of Preſſure, then the Height of this Mercury Q S will be to the Height of the Spirit Q N as the Specific Gravity (g) of the Spirit is to the Specific Gravity of Mercury (G), that is $Q S = \frac{g \times Q N.}{G}$

Again, when the Spirit ſtands at O, and the Mercury at T, if inſtead of Spirit, an equivalent Preſſure of Mercury were ſubſtituted; its Height $T V = \frac{g \times T O}{G}$. Hence P S will be the Height of the Mercury in the firſt Caſe; and R V will be the Height thereof in the latter; and therefore P S—R V will be the Difference of the Altitude of the Mercury in the *Simple Barometer* correſponding to that of N O in the *Compound one.*

Hence we have $P S = P Q - \frac{g \times Q N}{G}$, and $R V = R T - \frac{g \times T O}{G}$; and putting the Diameter of the equal Cylinders = D, and that of

of the ſmall Spirit Tube $= d$, we have $D^2 : d^2 :: NO : QT = \frac{d^2 \times NO}{D^2} = PR$ alſo. But $RT = PQ - 2\,PR = PQ - \frac{d^2 \times NO}{D^2}$. Whence $PS - RV = PQ - \frac{g \times QN}{G} - PQ + \frac{2\,d^2 \times NO}{D^2} + \frac{g \times TO}{G}$; that is $\frac{2\,d^2 \times NO}{D^2} - \frac{g \times QN}{G} + \frac{g \times TO}{G} = PS - RV = A$. But $TO - QN = NO - QT = NO - \frac{d^2 \times NO}{D^2}$; therefore

$$\frac{2\,d^2 \times NO}{D^2} + \frac{D^2 \times NO - d^2 \times NO}{G \times D^2} = A = \frac{2\,G - 1 \times d^2 x + D^2 x}{D^2 \times G},$$

putting $NO = x$. Whence, laſtly, we have $D^2 \times G \times A = 2\,G - 1 \times d^2 x + D^2 x$. Therefore $A : x :: 2\,G - 1 \times d^2 + D^2 : G \times D^2$.

Now in very cold Weather it is found by Experience, that the Specific Gravities of Mercury and Spirit of Wine are as 16 to 1; whence in that Caſe $2\,G - 1 = 31$; and ſo $A : x :: 31\,d^2 + D^2 : 16\,D^2$.

Laſtly, if we put $D : d :: 10 : 1$; then $A : x :: 131 : 1600 :: 1 : 12{,}21$; or the *Scale of Variation* in the compound Barometer is a little more than 12 Times as large as that of the ſimple Barometer without a *Vernier*, if the Parts have the Meaſures here aſſigned.

In very hot Weather we have $G : g :: 16{,}5 : 1$; and ſo $A : x :: 123 : 1650 :: 1 : 12{,}5$. In the ſimple Barometer the greateſt Scale of Variation is 3 Inches, in this compound one it

will be therefore, in very cold Weather, 36,64; and in very hot Weather 37,5; the Difference of which is 0,86 or 86 *Hundredth of an Inch.* And this Expanſion is all owing to the Rarefaction of the Spirit, that or the Mercury upon ſo large a Surface being quite inſenſible.

Upon this View of the Conſtruction of a *Compound Barometer*, it will be eaſy to obſerve, how very improper it is for philoſophical Uſes; for unleſs the two Baſons A D and I K are perfect CYLINDERS, and of an equal Diameter, the above Computation could not be made; nor any one at all, with theſe baſons of a bulbous or convex Surface, as is the uſual Form of them. Therefore unleſs made as the above Theory directs (and that will be found difficult enough) they can be of uſe only for a common Indication of Weather, without being capable of any *Scale of Rectification*, to render them worthy the Regard of a *Virtuoſo.*

All that has been hitherto ſaid about Barometers has been with regard to their Uſe on Land only, where they may be fixed and immoveable; but when we conſider their *Uſe at* SEA (and where perhaps it is moſt neceſſary, and conſequently greateſt of all) the Caſe becomes widely different, or rather quite contrary to the former; for the *Torricellian Barometer* can by no Means be uſed on board a Ship, by Reaſon of the great Agitation the Mercury is there ſubject to, and the Variety of Poſitions the Barometer muſt acquire from the Rowlings of the Ship. But in the *Compound Barometer*, the Mercury being confined, as it were, by the coloured Liquor, its Motion is but ſmall, and ſuch as is but little liable

liable to render the Inſtrument uſeleſs for obſerving the Changes of the Weather at Sea.

And becauſe the critical Uſes are not here required, therefore inſtead of *Cylinders*, the Baſons A D and I K may be of a globular or bulbous Form, as repreſented at the Top by the Curve (*a p e*) by which Means the Surface of the Quickſilver will be larger, its perpendicular Motion leſs of Courſe; alſo the *Scale of Variation* will, in this Caſe, become very large; and laſtly, the Structure of ſuch a MARINE BAROMETER would not be difficult or very expenſive, and it might be ſo contrived, that the Mercury could not be ſpoiled or loſt in caſe of an Accident, nor troubleſome to repair when out of order, by any ingenious Hand on board the Ship.

There is no neceſſity of enlarging further on this Subject; every Commander of a Ship I believe muſt be convinced, that the *Marine Barometer*, invented by Dr. HOOKE many Years ago, is not ſo ſimple in its Nature, not of ſuch immediate and ready Uſe, nor ſo eaſy to be repaired when out of Order, as one of the Form here propoſed.

Of the THERMOMETER.

AS to THERMOMETERS, Experience has taught us how extenſive their Uſe is in the *Commercial Arts*, as well as in the more curious Reſearches of PHILOSOPHY. The *Chemiſt*, the *Brewer*, the *Diſtiller*, the *Gardener*, find them neceſſary on many Accounts; the *Phyſician* is often directed by them to form a better Judgment of the Caſe of his *feveriſh Patient*; the *valetudinary Gentleman* thereby obſerves all the

different Temperatures of Air without Doors and within. And the *Virtuoſo* applies it to all the Purpoſes of Meteorology and Philoſophy.

As to the Fluid with which the *Thermometer* is filled, it is generally Quickſilver, becauſe that will exhibit all Degrees of Heat till it comes to boil, and therefore is far more convenient for Chemical Purpoſes, and many others where great Degrees of Heat or Cold are to be experimented. But the *Botanical Thermometer* for the *Green-houſe* is commonly filled with a red Liquor; and the Tube of a larger Bore will ſuffice for ſuch Degrees of Warmth as exotic Plants require.

The Forms and Sizes are many to anſwer different Deſigns; ſome are ſmall, of a Pocket or portable Form for the Phyſician, *&c.* Some very large, to contain a great Number of Diviſions for great Degrees of Heat. Some of a peculiar Form adapted to particular Occaſions, as the *Brewer's Thermometer*, *&c.*

The Manner of dividing the Scale is arbitrary, and may, for private Uſe, be any you pleaſe; but, for public Uſe, Cuſtom has made it neceſſary to have *Farenheit's* Method, ſuch as you ſee in the Thermometer A M in the Plate (Fig. 1.) where the Scale of the Degrees of Heat are on the left Side of the Tube, and on the right Side is the Scale K L of 26 equal Parts for *rectifying the Barometer*, as before deſcribed.

As all Degrees of Heat and Cold are *relative* to each other, and have no Term or Limit of Beginning or Ending, ſo there is properly no abſolute Point of Compariſon in ſuch a Scale, not even the *freezing Point* is fixed and determinate;

minate; though in this Scale it is placed at the 32d Diviſion. The *Temperate Point*, or Limit between Heat and Cold, is as yet unſettled; though uſually placed in this Scale at the 55th Degree. I think of nothing more neceſſary to be ſaid of Thermometers here, but that unleſs they are very carefully made, and well adjuſted by a *good Standard*, they will be of little Uſe or Certainty*.

Of the HYGROMETER.

AN HYGROMETER being that Inſtrument which is fitted for diſcovering the different Degrees of Moiſture and Dryneſs in the Air in general, but particularly that in the different Rooms and Apartments of the Houſe, cannot but be conſidered as extremely uſeful and neceſſary, and therefore it has a Place allowed it on the Top of the Plate (Fig. 1.) of the *Triple Weather-Glaſs*.

There are many Ways of making ſuch an Inſtrument, ſome better than others; but as there would be no End in deſcribing them, I ſhall content myſelf with recommending here, that which I judge to be the moſt natural and ſimple. It conſiſts of a circular Braſs Box, about $2\frac{1}{2}$ wide, and $\frac{1}{2}$ an Inch deep, with a ſilvered Plate and graduated Circle on the Bottom, on one Side of which is engraved the Word MOIST, and on the other Side the Word DRY; on the Center of the Plate, or Bottom, is fixed a Part of the twiſted Beard of a

* See my Treatiſe on the New Conſtruction of a *Standard Thermometer*, ſhewing all Degrees of *Heat* and *Cold*, from boiling Mercury to its fixed State.

a *Wild Oat*, on which is placed a very light Index which moves over the Diviſions on the Sides of the Box, by the Spiral of the Oat, twiſting and untwiſting with the Moiſture and Dryneſs of the air, by which thoſe qualities are ſhewn, ſo neceſſary to be known.

As nothing can be more prejudicial to a Perſon's Health than a very moiſt or damp Air, ſo this Inſtrument may be looked upon as a *Nuncio* of Salubrity; for which Reaſon it is much to be valued and regarded. And thoſe who will take Pains, and proper Care to regulate it (which is too often neglected) may find it not in vain. However it is not to be expected that the *Hygrometer* ſhould be as perfect in its nature as the *Barometer* and *Thermometer*; becauſe nothing is yet found to receive and part with the Particles of Moiſture in an inſtantaneous or equable Manner. Theſe Particles are quickly attracted by the Cord, but not ſo ſuddenly expelled by the action of Heat which occaſions Dryneſs.

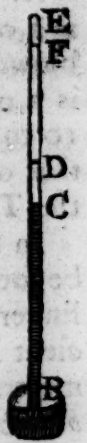
Having thus explained, and put together in one Frame, theſe three capital and important Inſtruments which conſtitute an *univerſal* METEOROSCOPE or *Triple* WEATHER-GLASS; I know of nothing more that I can do to ſerve the Public in this Reſpect, but *furniſhing them with the Inſtrument itſelf well made.*

APPENDIX.

APPENDIX.

I Think of but one Objection that the preſent Form of the Barometer I have here recommended, is liable to, and that is the Want of a large hollow Globe or Ball which has been uſually blown upon the Top or cloſe End of the Tube, whoſe Uſe was to receive the Air which might remain in the Tube after it was filled, and by giving it a great deal of Room to expand itſelf, prevent its obſtructing the Riſe of the Quickſilver as much as poſſible.

In anſwer to this, I can only ſay, that ſuch a Bubble is but too plain an Argument that they who think it neceſſary, are not acquainted with the true and genuine Method of filling the Tube with Mercury, which leaves no Room to ſuſpect any Remainder of Air that can have the leaſt ſenſible effect on the Altitude of the Mercury in the Barometer.



But that the *Mathematical Reader* may have it eaſily in his Power to judge of this Matter, I ſhall here give a *New Solution* to that curious *Barometrical* Problem of the celebrated Mr. Cotes,* and I think more direct and ſimple than any one I have yet ſeen. The Problem is this, *having given the Height of Mercury* BD *in the Tube, which is equal to the Weight of the Atmoſphere at a given Time, it is propoſed to find the Deficiency* CD *from the Height occaſioned by the Spring of a given Quantity of Air* EF *at the Top of the Tube.* Put BD = *a*, DD = *b*, EF = *c*, and DC = *x*; then becauſe the

* See his *Hydroſtatical* Lectures Page 85, 86, &c.

the Spring S of the Air in E F is equal to that of the external Air = B D = B C + C D; and becauſe the ſaid Weight of the atmoſphere is alſo equal to the Column of Mercury B C and Spring (s) of the included Air, now expanded into the Space E C; therefore we have S = B D; and s = B D — C B = D C. Hence it is S : s : : BD : DC.

But we have ſhewn elſewhere, * *That the Spring of the ſame Quantity of Air is reciprocally as the Space it poſſeſſes.* Therefore S : s : : C E : F E; and conſequently we have C E : F E : : B D : D C, that is, $b + x : c :: a : x$, which gives $x^2 + b x = a c$; the Square compleated, and the Root extracted, gives $x = \sqrt{a c + \frac{b^2}{4}} - \frac{1}{2} b$ = D C. Q. E. I.

Example; ſuppoſe B D = a = 30, D E = b = 4, and E F = c = 0,025; then x = D C = 0,17, the Deficiency from the true Altitude B D. The Space C F = 4,17 the half thereof is 2,085. Hence ſuppoſe the Top of the Tube blown into the Form of a Cylinder, whoſe Length is 2,085, and Diameter to that of the Tube as 10 to 1; then would its Capacity be 50 times that of C F, or equivalent to 208,5 Inches of the Tube.

In this Caſe b = 208,5; and x = D C, will be found about 0,05; and therefore ſuch a Cylinder, or Globe equal to it, will prove a ſufficient Reſervoir for the *ſubreptitious Air* in Barometers, where no great Nicety is required. When b = 0, or *negative* ($-b$) the Value of x is found = $\sqrt{a c}$, or $x = \sqrt{a c + \frac{1}{4} b^2} + \frac{1}{2} b$.

* See Mathematical Inſtitutes, Vol. II. Page 303, &c. in the General Magazine of Arts and Sciences.

FINIS.